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33/127 47/00 47/01 , F16L 55/26 55/44
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(54) Abstract Title
**Self contained pumping sub for well logging tools**

(57) A well logging tool(30 Fig3) is connected to a pumping sub(34 Fig3) and inserted into a drill pipe(14). The sub(34 Fig3) has two identical inflatable bladders(302,304), connected end to end. Bladder(302) is primarily used to enable the logging tool(30 Fig3) to be pumped down the drill pipe(14). Bladder(304) is primarily used to enable the tool to be pumped up the drill pipe(14) and also when the logging tool(30 Fig3) is dropped down the drill pipe(14) it forms a parachute slowing the fall of the logging tool(30 Fig3). Bladder(302) operates by having an inflatable bladder(306) which is surrounded by a cage of wires(308). The wires(308) are connected to two cylindrical sections(310,312) and hold the two sections(310,312) in a spaced apart relationship. Bladder(306) is inflated by a piston(314) and cylinder(316) arrangement. Cylinder(316) is full of fluid and the piston(314) is urged by a spring(318) to force fluid to inflate the bladder(306). A two way relief valve(326) prevents fluid in the well bore under normal conditions from passing through an inner hollow tubular section(322), but should the pressure of the fluid become too high, the valve(326) allows the fluid to pass into the centre section(312) within hollow tubular member(322) via an inlet hole(324).The central cylindrical portion(312) has outlet mud flow vents(328). An apparatus(400 Fig6) for inserting a pumping sub is also described.

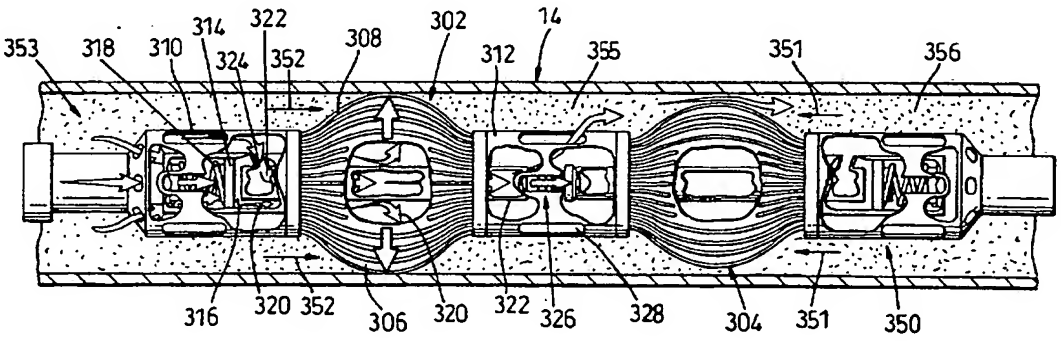


*Fig. 4*

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

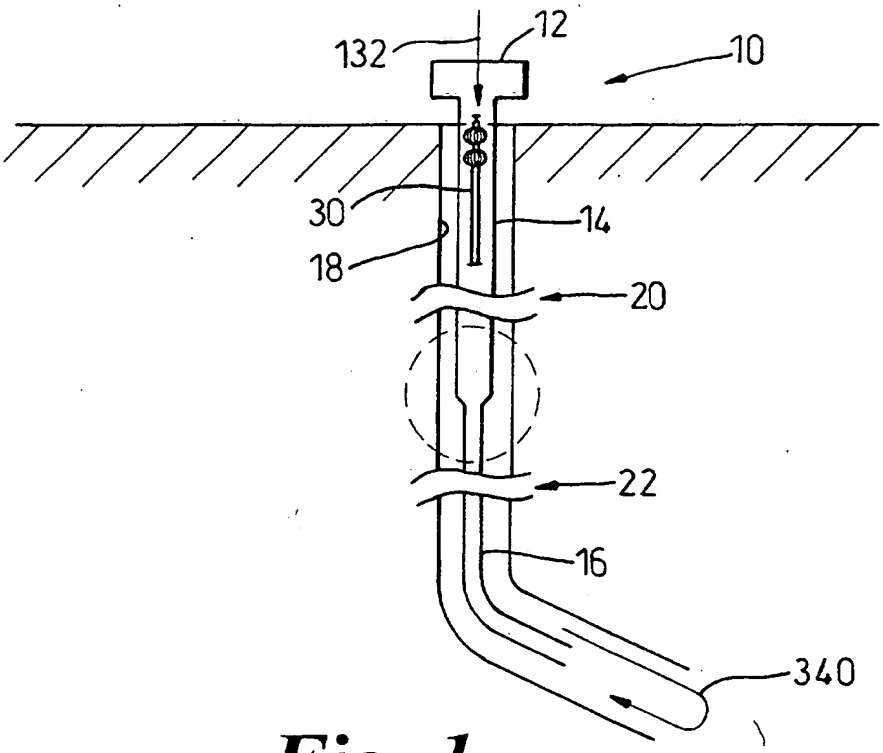


*Fig. 1*

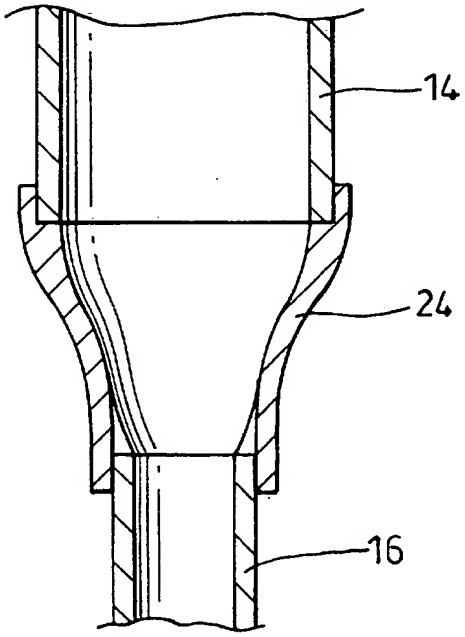


*Fig. 2*

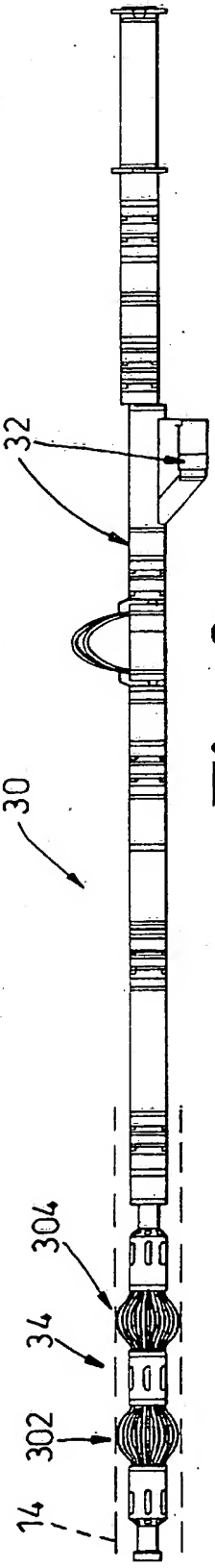
32
30
304
34
302
14

Fig. 3

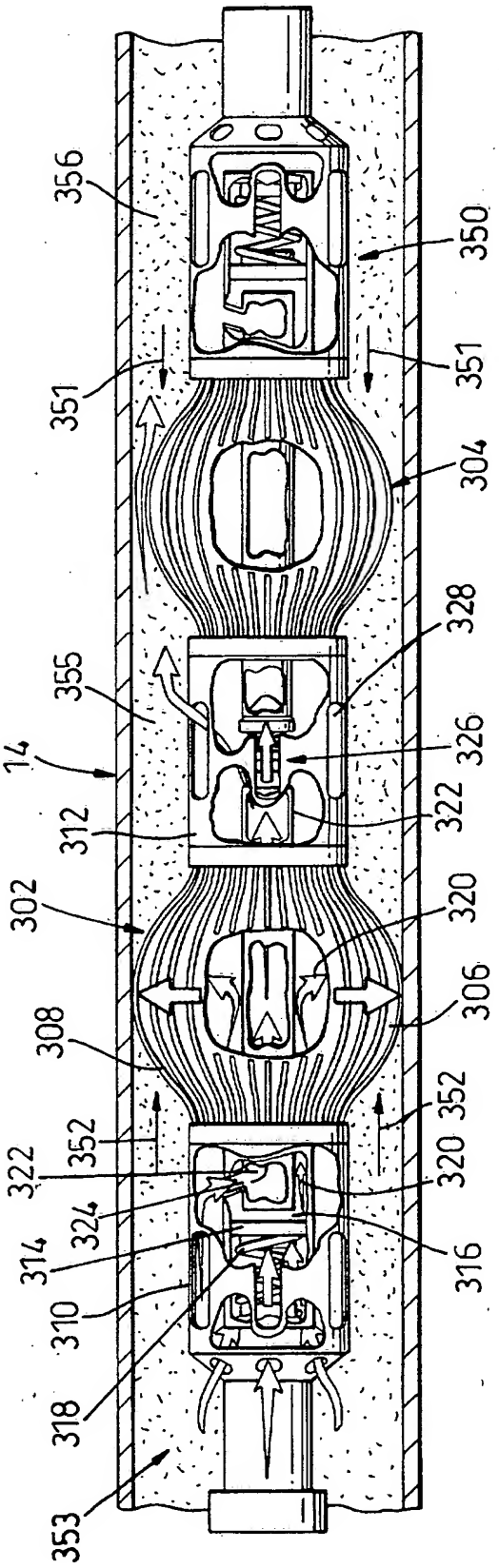
356
350
351
351
304
328
355
326
14
322
312
302
320
306
308
352
352
322
320
324
314
316
310
318
353

Fig. 4

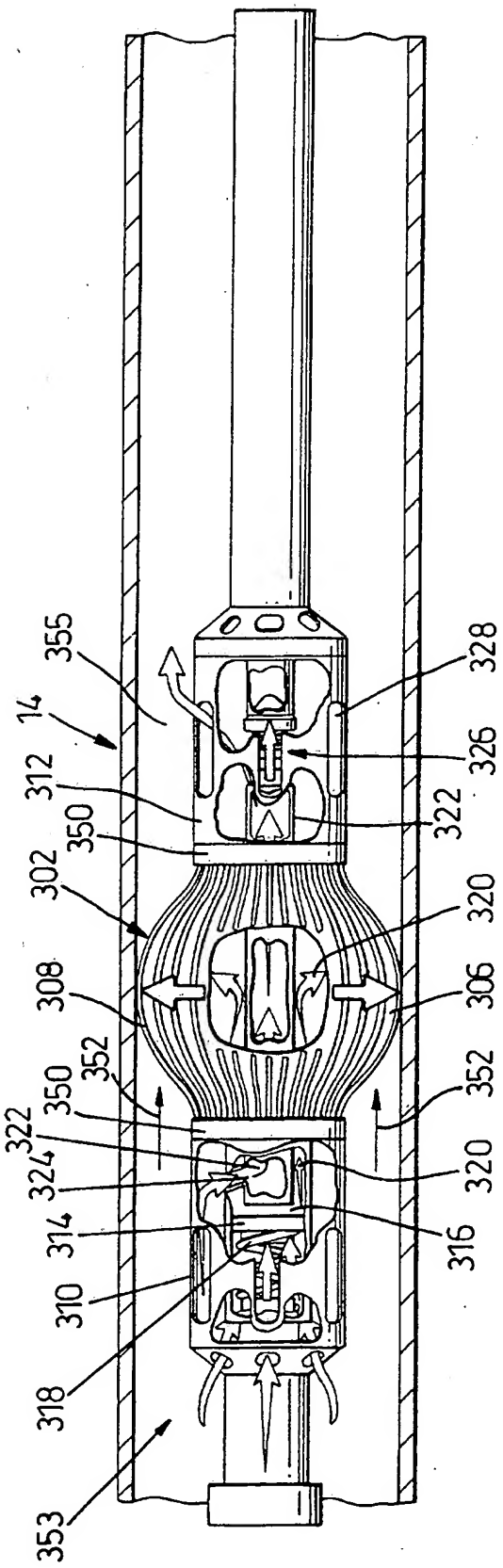
355
14
312
350
302
308
352
350
322
324
314
310
318
353
328
326
322
320
306
352
320
316

*Fig. 5*

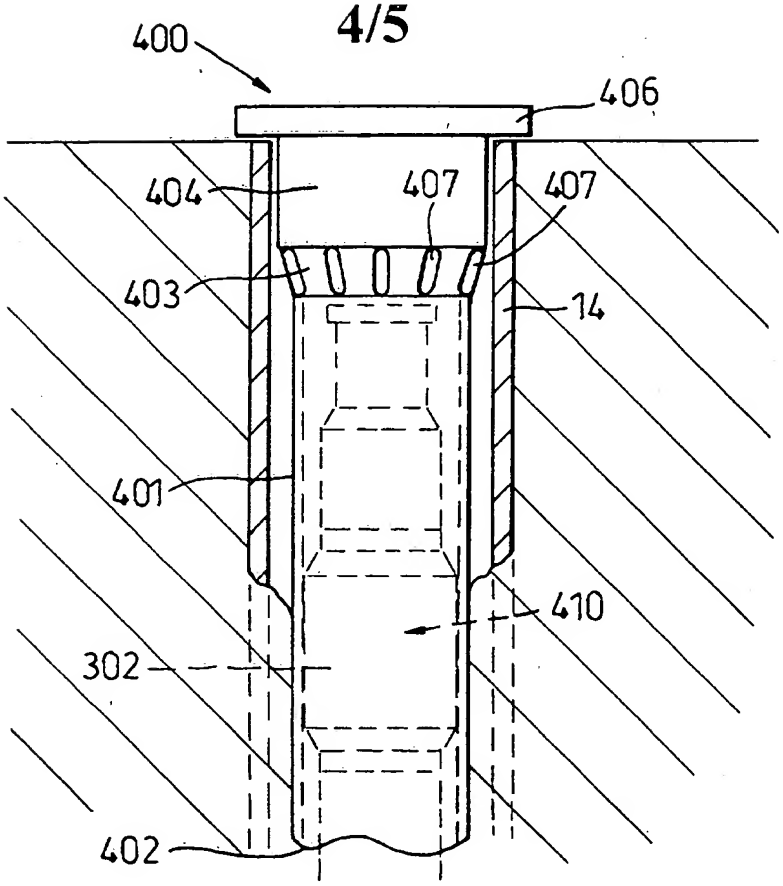
400
406
404
407
407
403
14
401
410
302
402

*Fig. 6*

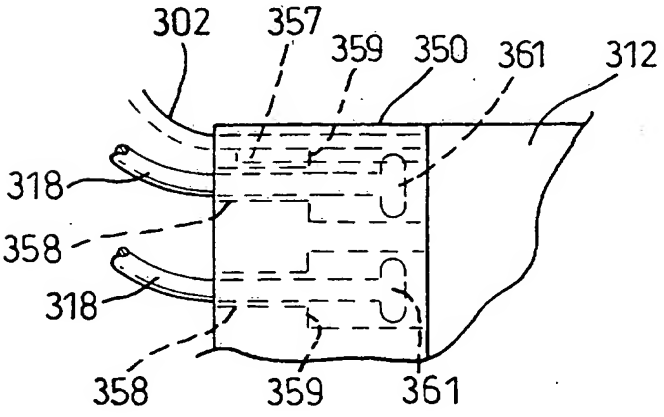
302
357
359
350
361
312
318
358
318
358
359
361

*Fig. 7*

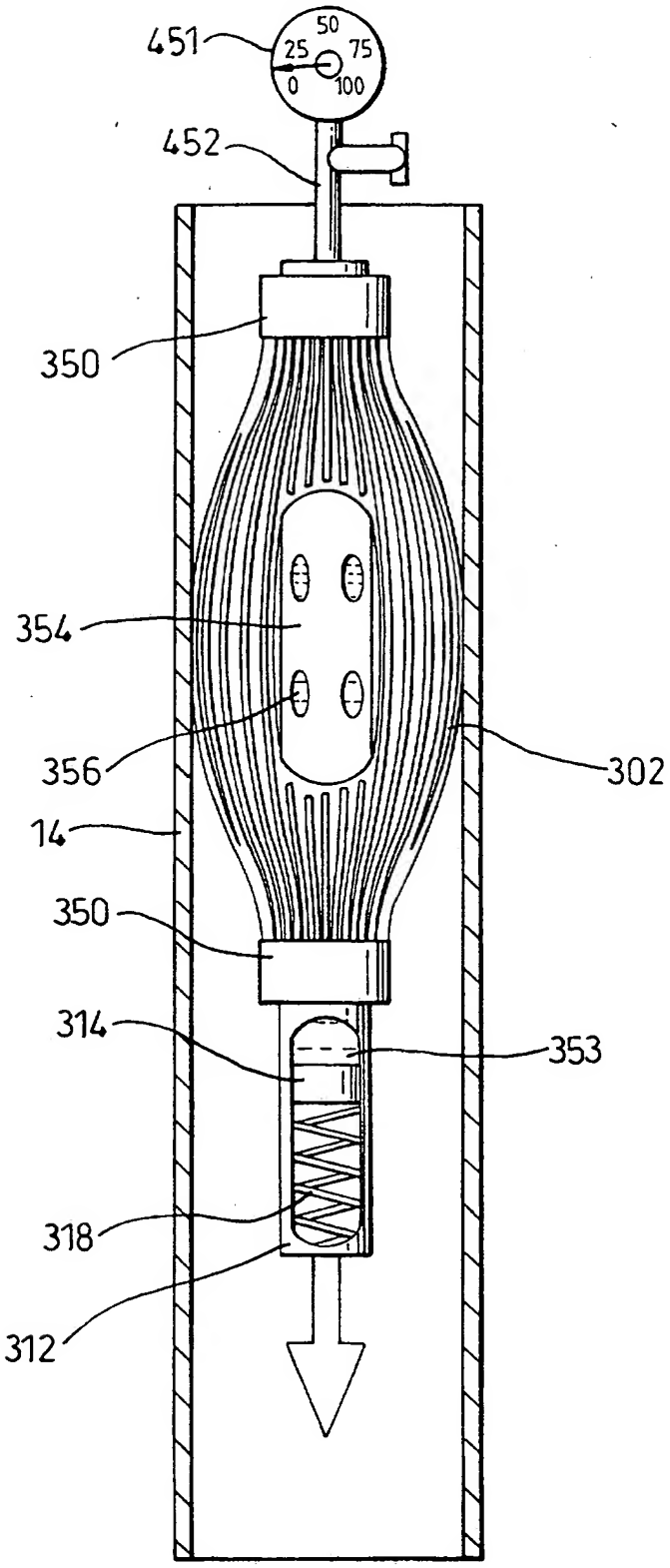


*Fig 8*

# PUMPING SUB FOR WELL LOGGING TOOLS

The present invention relates to a pumping sub for a well logging tool and more particularly to a novel seal arrangement enabling a logging tool to be lowered into a drill pipe and also to be pumped back up a drill pipe.

The invention finds particular advantage with self contained logging tools which are not connected by cable to the top of a drill hole. Such tools require to be moved along the drill pipe to a desired position and mud pressure is normally used to effect such movement. Reversal of mudflow is used to effect movement of the tool in reverse directions.

The novel seal arrangement in the present invention acts as a piston for use when a self contained well logging tool is deployed inside a drill pipe in order to enable it to be transported to and from parts of the well from which data is to be gathered.

In a typical well many "strings" of drill pipe can be made up from lengths that may have different diameters, usually getting progressively smaller towards the bottom of the hole.

Presently, cone seals are used but these conventional cone seals have difficulty coping with these different diameters. Also, the cone seals are problematic when being used bi-directionally while maintaining a reasonable seal.

It is an object of the present invention to provide a seal arrangement which can cope with various diameters of drill pipe and which, in a preferred embodiment, can be used bi-directionally.

The present invention, therefore, provides a pumping sub for use in a drill pipe, said pumping sub comprising inflatable bladder means, said inflatable bladder means being adapted to expand to conform to the diameter of a drill pipe when inserted into said drill pipe.

Preferably, the inflatable bladder means comprises an inner inflatable bladder situated within a cage of spring wires and in which internal pressure within said bladder causes said spring wires to move outwardly with increase in size of said bladder to conform to the internal diameter of a drill pipe into which said pumping sub is inserted.

Preferably, said bladder is provided with piston means operative to supply pressurized fluid to said bladder to inflate said bladder.

Preferably, said piston means is situated within a cylinder and said piston means is provided with spring means creating pressure (i.e. a force) on said piston means, in which said cylinder means is filled with fluid and in which said cylinder means is connected to said bladder means to thereby create continual pressure within said bladder means.

In a preferred embodiment said piston means is situated at a first end of said bladder means.

In a second embodiment mud flow inlet means is provided adjacent to said piston means to allow mud to flow past said piston means and passageway means is provided through a central portion of said bladder means and connected to said mud flow inlet means to allow mud to flow through the bladder means, and in which said passage means is connected to relief valve means operative to allow passage of mud through said mud flow inlet means and said passageway means when said mud flow pressure

exceeds a maximum value.

In a preferred embodiment said pumping sub comprises two inflatable bladder means mounted in tandem but with opposite hand, each said bladder means being provided with mud flow inlet means and passageway means, said passageway means each being provided with relief valve means.

Preferably said relief valve means for said two inflatable bladder means are combined into a single bi-directional relief valve means.

The seal, according to preferred embodiments of the present invention, adapts to different diameters by using an inflatable bladder inside a cage of spring wires which serve to protect the bladder from abrasion and also to profile the bladder to allow it easy passage over steps in the drill pipe diameter. The bladder is kept inflated by the action of a spring acting on a piston in a hydraulic cylinder forcing oil into the bladder to maintain it at a low positive pressure with respect to the bore-hole pressure. The piston arrangement is oriented in such a way that the differential pressure across the seal adds to the inflation pressure. It is not necessary for the seal to seal absolutely (the wire cage prevents this) as the viscosity of the fluid passing around the small space around the seal is such that sufficient differential pressure is developed across the seal to enable it to act correctly. It is often the case that it is not necessary to pump the tool down the well, the weight of the tool providing enough force to cause the tool to descend, in this case the seal acts as a "parachute" to slow down the descent speed. If the well is highly deviated, pumping has to be used.

Preferably the inflatable bladder situated within a cage of spring wires and

in which internal pressure within said bladder causes said spring wires to move outwardly with increase in size of said bladder to conform to the internal diameter of a drill pipe into which said pumping sub is inserted, wherein the inflatable bladder is a hollow member having an opening at either end, the bladder being secured, about the periphery of each said opening, to a housing by means of an anchoring collar that grips the bladder and secures it relative to the housing

This arrangement advantageously ensures that as the bladder inflates and deflates the material of the bladder (that in preferred embodiments is a resiliently deformable, hollow sleeve) is not pulled out of engagement with the other components of the pumping sub.

Conveniently each spring wire is received at each end in a respective aperture in a said anchoring collar, each said aperture defining a shoulder facing away from the bladder and each said spring wire including secured thereto a portion lying to the side of the shoulder remote from the bladder and so shaped and/or dimensioned as to be incapable of passing beyond the shoulder towards the bladder, whereby the spring wire is slideably captive relative to the anchoring collar. This arrangement advantageously ensures that the spring wires are also efficiently retained relative to the other components of the pumping sub.

In a preferred embodiment a second seal assembly is connected to the first one and is disposed in such a way to allow the tool to be pumped out of the well to recover the data recorded by the logging tool.

A system of fluid passages and relief valves between the two seals allows the pressure to be released should the tool become stuck in the well.

According to a second aspect of the invention there is provided an apparatus for inserting an inflated pumping sub into a fluid filled drill pipe, the apparatus including a hollow, generally cylindrical sleeve of smaller outer diameter than the internal diameter of a drill pipe and into which the pumping sub is insertable via an opening at an in use lower end thereof, an upper portion of the sleeve including one or more passages providing fluid communication between the interior and exterior of the sleeve whereby on insertion of a said sleeve containing a said pumping sub into a said drill pipe, so that the level of fluid reaches the said passage, the said fluid flows into the sleeve above the pumping sub to equalise fluid pressure on either side thereof and permit subsequent removal of the sleeve from the pumping sub.

This arrangement advantageously permits insertion of the pumping sub, in a quick and convenient manner, into a drill pipe that is filled with a fluid and especially an incompressible fluid such as water or drilling mud.

Conveniently the sleeve includes a vent that in use lies above the said passage.

This feature advantageously facilitates displacement of air from the interior of the sleeve that in use lies above the bladder of the pumping sub.

The sleeve of the said apparatus also advantageously includes one or more exterior projections that in use of the apparatus lie above the said passage and engage a drill pipe into which the sleeve is inserted, thereby retaining the sleeve at the top of the drill pipe. The projection, that in preferred embodiments is a peripheral flange protruding from the sleeve, prevents

the sleeve from dropping down the drill pipe during insertion of the pumping sub.

Embodiments of the present invention will now be described with reference to the accompanying drawings in which:-

Figure 1 shows an exemplary well illustrating various sizes of drill pipe,

Figure 2 shows the portion of the well of Figure 1 delineated by dotted lines in greater detail,

Figure 3 shows a logging tool incorporating a preferred embodiment of the pumping sub of the present invention;

Figure 4 shows an embodiment of the pumping sub of the present invention as illustrated in Figure 3 in position in a drill pipe and being shown in partial longitudinal cross section;

Figure 5 shows another embodiment of the invention employing a single bladder assembly;

Figure 6 shows a partly sectioned view of an apparatus, according to an aspect of the invention, for inserting a pumping sub as shown in Figure 4 or Figure 5, into a mud filled drill pipe;

Figure 7 shows in detail an attachment for the resiliently deformable wires of the bladders of the figure 4 and 5 embodiments; and

Figure 8 shows another embodiment of the invention employing a single bladder.

With reference now to Figure 1, a typical well 10 comprises a head end 12 and lengths of drill pipe 14, 16 situated within a drill hole 18.

The hole 18 is shown broken at points 20, 22 to indicate that the hole is long. The hole can be several thousand metres (yards) long.

The drill pipe 14 may typically be of 6 inch (150 mm) initial diameter and at some point this is connected to a drill pipe 16 which may typically be of 5 inch (125 mm) diameter.

As is illustrated in Figure 2, the two drill pipes will be jointed by suitable conversion collar means 24 suitably threaded in to both pipes 14, 16. (Figure 2 exaggerates the different diameters for illustration purposes).

A well logging tool 30 is inserted into the drill pipe 14 in known manner.

The tool 30 may descend the drill pipe either under the force of gravity or by use of mud pressure indicated by arrow 32.

Usually, particularly when descending the wider diameter pipe 14, the tool, which is fairly heavy, descends rapidly under gravity. The tool can accelerate to unacceptable speeds and could possibly damage itself if it encountered an obstacle.

One of the advantages of the present invention is that the pumping sub provides a "parachute" which controls the descent of the logging tool in the drill pipe as will be explained hereinafter.

The logging tool can be forced back to the surface by reversal of mud flow direction as indicated by arrow 340.

With reference now to Figure 3, the logging tool 30 comprises an electronic data recording section 32 which in the present invention is attached to a pumping sub section 34.

In a preferred embodiment, as shown in figures 3 and 4, the pumping sub is provided with two inflatable bladders 302, 304.

The logging tool 30, including the pumping sub, is lowered into the drill pipe 14 as shown dotted in Figure 3, the left-hand and being the uphole side.

The construction and operation of the pumping sub will now be described with reference to the more detailed partial cross sectioned drawing of Figure 4.

In essence, each bladder assembly 302, 304 is substantially identical, bladder assembly 302 forming a left-hand assembly and bladder assembly 304 forming a right-hand assembly.

Bladder assembly 302 may be designated a pump down bladder, since its primary purpose is to enable the logging tool to be pumped down the drill pipe.

Bladder assembly 304 may be designated a pump up and parachute bladder, since it performs two functions, firstly enabling the logging tool to be pumped up the drill pipe and when the logging tool is dropped down the drill pipe the bladder assembly 304 forms a parachute slowing the fall of the logging tool.

The operation of bladder assembly 302 is as follows. The bladder assembly comprises an inflatable bladder 306 which is surrounded by a cage of wires 308. The wires are connected to two cylindrical sections 310, 312 and hold these two sections in a spaced apart relationship.

Bladder 306 is inflated by a piston 314 and cylinder 316 arrangement. The cylinder 316 is full of fluid and piston 314 is spring urged by compression spring 318 to force fluid in the direction of arrows 320 to inflate bladder 306.

The piston 314 is of complex shape and includes an inner hollow tubular section 322 which has mud inlet hole 324. The inner hollow tube allows mud under pressure to pass in to the centre section 312 within hollow tubular member 322 where in normal operation said flow is prevented by a two way relief valve 326, the operation of which will be explained hereinafter.

The central cylindrical portion 312 is provided with outlet mud flow vents 328 and is also connected at its right-hand end to bladder assembly 304 which as stated above is substantially identical to bladder assembly 302, but which is a right-hand assembly as opposed to a bladder assembly 302 which is a left-hand assembly.

The operation of the pump sub assembly comprises four separate modes.

In a first mode the logging tool is dropped down the drill pipe 14.

In this mode mud 350 which fills the drill pipe effectively exerts pressure in the direction of arrows 351. This pressure, together with the internal pressure provided by piston 314 (in the bladder assembly 304), expands bladder 304 and provides an effective parachute slowing down the fall of the logging tool 30.

In a second mode, as shown in Figure 4, it is assumed that the logging tool 30 has to be pumped down the drill pipe.

In this case mud pressure is exerted on to bladder assembly 302 in the direction of arrows 352.

This pressure adds to the inflationary pressure of piston 314 and further expands the bladder 306 thereby providing a force to push the logging tool down the drill hole. It is noted that because the bladder 306 is surrounded by spring wires 308 some mud will flow past the bladder, but a differential pressure will exist across the bladder between spaces 353 and 355 in the drill pipe.

In a third mode of operation it is assumed that the logging tool is being returned to the surface or moved along the drill pipe towards the surface by reverse mud flow.

The operation is then the reverse of the second mode, within this mode mud pressure being applied in the direction of arrows 351. Differential pressure across spaces 356 and 355 will cause bladder assembly 304 to expand as in the case of bladder assembly 302 and to thereby close off the drill pipe creating an upward force on the logging tool.

In a fourth mode of operation, it is assumed that the logging tool has become stuck, such that pressure will build up in the pipe in the area 353.

In this situation the two way pressure relief valve 326 will open allowing mud to flow via mud inlet 324 hollow tubular section 322 and valve 326.

The mud will flow into space 355 in the drill pipe and will equalise pressure on both sides of bladder assembly 302. This will partially deflate the bladder and release sideways pressure on the drill pipe, thereby

freeing the logging tool allowing it to pass any obstruction.

Whilst Figure 4 illustrates the tool movement down the pipe, the relief valve 326 will operate in similar manner to facilitate freedom for movement when logging tool is being moved up the pipe.

As can be seen from the above description, the bladder assemblies 302, 304 will expand to fill (within design limits) pipes of different diameter, for example, 5 inch (125 mm) and 6 inch (150 mm) pipes. As the pumping sub passes from one diameter of pipe to another the spring wires allow the diameter of the bladder to automatically change to accommodate the new size.

The spring steel wires prevent damage to the bladder and provide a smooth surface contour assisting in the transition between pipe sizes.

Referring now to Figure 5, there is shown another embodiment of pumping sub in accordance with the invention, including only a single bladder 302.

Bladder 302 is similar to bladder 302 of Figure 4, in that it comprises an elongate, hollow, cylindrical, resiliently deformable sleeve of e.g. rubberised material. The sleeve is open at either end and is secured at each open end to the remainder of the pumping sub by means of anchoring collars 350 described in more detail below.

The anchoring collars 350 also retain a plurality of longitudinally extending spring wires 308 that constrain expansion of bladder 302 in a manner as aforesaid.

At one end (the uphole end in Figure 5) the pumping sub of the invention includes a hollow cylindrical housing 310 having through-going vents providing communication between the interior and exterior thereof.

Within housing 310 there is provided an inner hollow tubular section 322 having slidably secured in an inner bore thereof a piston 314 that is urged to the right in Figure 5 by spring 318.

Piston 314 acts on e.g. drilling mud to its right within tubular section 322. Tubular section 322 protrudes into the interior of bladder 302, whereby pressure exerted on the mud by piston 314 inflates bladder 302 until it occupies substantially the entire cross-section of the drill pipe.

Tubular section 322 includes a mud inlet hole 324 for feeding mud to housing 312 that lies to the right of bladder 302 in Figure 5.

Housing 312 includes a one way relief valve in the Figure 5 embodiment, whereby when mud pressure at the up-hole side of bladder 302 exceeds the bias pressure of the valve 326 the latter opens (as illustrated in Figure 5) to allow the passage of mud out of housing 312 via vents 328. This reduces mud pressure at the up-hole side of bladder 302, with the result that the pumping sub is removable from the drill pipe at all times.

Figure 8 shows another form of pumping sub according to the invention that employs a single bladder 302, that may be of substantially similar construction to the bladders of Figures 4 and 5.

In the Figure 8 arrangement the spring 318 and piston 314 are movably located within the central bore of housing 312 on the down-hole side of bladder 302.

In the Figure 8 embodiment the up-hole side of bladder 302 communicates via pipe 452 to a bladder pressure gauge 451, for the purpose of monitoring the pressure within bladder 302 in a test rig situation. However, the anchoring collar 350 at the up-hole side of bladder 302 in Figure 8 may equally well be connected at the up-hole end to a housing 310 containing e.g. a one-way pressure relief valve having a biasing pressure chosen to permit pressure equalisation in the event of the bladder 302 becoming stuck in when moving in the down-hole direction.

As in the other embodiments of the invention, in the Figure 8 embodiment a piston 314 pressurises a column of fluid 353 within the resiliently deformable member defining the bladder 302, by means of a cylinder 356 having apertures opening into the interior of bladder 302, cylinder 354 being an extension of housing 312.

The spring 318 acting on piston 314 causes inflation of bladder 302 until bladder 302 occupies substantially the entire cross-section of drill pipe 14, whereby the apparatus is substantially self-limiting.

As noted by the exemplary figures in Figure 8, when drill pipe 14 is a 5 inch internal diameter pipe the bladder 302 contacts the interior wall of drill pipe 14 over approximately a 6 inch length thereof.

Under such circumstances housing 312 is able to support up to a 350 pound load constituted by the remainder of the logging tool connected thereto, while the sub remains pumpable up and down the drill pipe 14.

Referring now to Figure 7 there is shown in detail one embodiment of anchoring collar 350 suitable for retaining the spring wires 318 and the

bladder 302 relative to the housings 310, 312 at either end of the pumping sub in the embodiments of Figures 4, 5 and 8.

Anchoring collar 350 is a rigid annulus of greater diameter than an open ended spigot 357 protruding from a hollow housing such as housing 312 adjacent an end of bladder 302.

Spigot 357 is of smaller external diameter than the internal diameter of the annulus defining anchoring collar 350, by an amount that is slightly less than the thickness of the material of bladder 302. Consequently on assembly of the pumping sub it is possible to trap the material of bladder 302 adjacent one of the open ends thereof between the interior wall of anchoring collar 350 and the exterior wall of spigot 357, such that anchoring collar 350 grips bladder 302 onto spigot 357.

As a result when bladder 302 inflates under the action of piston 314 the material of bladder 302 is sealingly retained relative to .e.g. housing 312.

Each spring wire 318 is received in a through-going bore 358 extending longitudinally through collar 350. Each bore 358 defines a shoulder 359 that is directed away from the body of bladder 302. In other words the diameter of each bore 358 widens at a shoulder 359 part way between the opposite sides of collar 350.

Each spring wire 318 terminates in a thickened portion 361 that is a slidable fit in its associated bore 358 to the right of Figure 7; but is too large to pass through the portion of bore 358 to the left of shoulder 359. Consequently each spring wire 318 is retained slidably captive relative to collar 350.

This in turn allows extension of each spring wire 318 during expansion of bladder 302, without a risk of any of the spring wires 318 emerging completely from its associated bore 358.

Referring now to Figure 6 there is shown an apparatus 400 for inserting a pumping sub such as that shown in any of Figures 4, 5 or 8, into a drill pipe 14 filled with e.g. drilling mud.

The apparatus 400 is desirable because the action of piston 314 in inflating bladder 302 makes it difficult to insert the pumping sub into the drill pipe 14, especially when the latter is full to the brim with drilling mud (that is of course incompressible).

Apparatus 400 comprises a hollow, generally cylindrical sleeve 401 that is open at a lower end 402 whereby the pumping sub 410 is insertable therein such that the bladder 302 inflates to occupy substantially the entire cross-section of the hollow interior of sleeve 401.

The external diameter of sleeve 401 is over the bulk of its length somewhat less than the internal diameter of drill pipe 14.

Adjacent its upper end sleeve 401 is outwardly flared at 403 so that an uppermost portion 404 of sleeve 401 is of a diameter only slightly less than the internal diameter of drill pipe 14.

In the embodiments shown the very top of sleeve 401 terminates in an outwardly directed flange 406 that is of greater external diameter than the open, upper end of drill pipe 14.

At flared portion 403, sleeve 401 includes an annular series of through-

going passages 407 providing fluid communication between the interior and exterior of sleeve 401.

When pumping sub 302 is inserted into the open lower end of sleeve 401 the bladder 302 inflates.

The assembly comprising pumping sub 302 (that is in practice of course jointed to the remainder of a logging tool) and sleeve 401 is readily insertable into drill pipe 14, by virtue of the outer diameter of sleeve 401 being less than the inner diameter of drill pipe 14.

Initially as the lower portion of 401 is submerged into the drilling mud, the pressure of drilling mud acting on a lower portion of pumping sub 302 within sleeve 401 prevents separation of sleeve 401 from pumping sub 410.

However, as the flared portion 403 of sleeve 401 becomes immersed, drilling mud flows via the passages 407 into the hollow interior of sleeve 401 to equalise the mud pressure above the bladder 302 with that acting below. Thereafter it is comparatively easy to withdraw sleeve 401 from pumping sub 410, whereby pumping sub 410 is then submerged within drill pipe 14.

On removal of sleeve 401, bladder 302 inflates further to occupy substantially the entire cross-section of drill pipe 14. Thereafter pumping sub 410 is pumpable up and down in drill pipe 14 in a manner as aforesaid herein.

Flange 406 prevents sleeve 401 from dropping down inside drill pipe 14 during pumping sub insertion operations.

The upper end of portion 404 may if desired be vented to assist in displacement of air from within the interior of sleeve 401 as drilling fluid passes through the passages 407.

The uppermost end of sleeve 401 may in some embodiments be completely open, whereby a member may be applied to the uppermost end of pumping sub 410 in order to retain it in place while the sleeve 401 is withdrawn upwardly therefrom.

## CLAIMS

1. A pumping sub for use in a drill pipe, said pumping sub comprising inflatable bladder means, said inflatable bladder means being adapted to expand to conform to the diameter of a drill pipe when inserted into said drill pipe.

2. A pumping sub as claimed in Claim 1 in which the inflatable bladder means comprises an inner inflatable bladder situated within a cage of spring wires and in which internal pressure within said bladder causes said spring wires to move outwardly with increase in size of said bladder to conform to the internal diameter of a drill pipe into which said pumping sub is inserted.

3. A pumping sub as claimed in Claim 2 in which said bladder is provided with piston means operative to supply pressurized fluid to said bladder to inflate said bladder.

4. A pumping sub as claimed in Claim 3 in which said piston means is situated within a cylinder and said piston means is provided with spring means creating pressure on said piston means, in which said cylinder means is filled with fluid and in which said cylinder means is connected to said bladder means to thereby create continual pressure within said bladder means.

5. A pumping sub as claimed in Claim 4 in which said piston means is situated at a first end of said bladder means.

6. A pumping sub as claimed in Claim 5 in which mud flow inlet means is provided adjacent to said piston means to allow mud to flow past

said piston means and passageway means is provided through a central portion of said bladder means and connected to said mud flow inlet means to allow mud to flow through the bladder means, and in which said passage means is connected to relief valve means operative to allow passage of mud through said mud flow inlet means and said passageway means when said mud flow pressure exceeds a maximum valve.

7. A pumping sub as claimed in Claim 1 in which the inflatable bladder means comprises an inner inflatable bladder situated within a cage of spring wires and in which internal pressure within said bladder causes said spring wires to move outwardly with increase in size of said bladder to conform to the internal diameter of a drill pipe into which said pumping sub is inserted, wherein the inflatable bladder is a hollow member having an opening at either end, the bladder being secured, about the periphery of each said opening, to a housing, by means of an anchoring collar that grips the bladder and secures it relative to the housing.

8. A pumping sub as claimed in Claim 1 in which the inflatable bladder means comprises an inner inflatable bladder situated within a cage of spring wires and in which internal pressure within said bladder causes said spring wires to move outwardly with increase in size of said bladder to conform to the internal diameter of a drill pipe into which said pumping sub is inserted, wherein the inflatable bladder is a hollow member having an opening at either end, the bladder being secured, about the periphery of each said opening, to a housing by means of an anchoring collar that grips the bladder and secures it relative to the housing; and wherein each said spring wire is received at each end in a respective aperture in a said anchoring collar, each said aperture defining a shoulder facing away from the bladder and each said spring wire including secured thereto a portion lying to the side of the shoulder remote from the bladder and so shaped

and/or dimensioned as to be incapable of passing beyond the shoulder towards the bladder, whereby the spring wire is slideably captive relative to the anchoring collar.

9. A pumping sub as claimed in any one of claims 2 to 8 wherein said pumping sub comprises two inflatable bladder means mounted in tandem but with opposite hands, each said bladder means being provided with mud flow inlet means and passageway means, said passageway means each being provided with relief valve means.

10. A pumping sub as claimed in Claim 9 in which said relief valve means for said two inflatable bladder means are combined into a single bi-directional relief valve means.

11. An apparatus for inserting an inflated pumping sub into a fluid filled drill pipe, the apparatus including a hollow, generally cylindrical sleeve of smaller outer diameter than the internal diameter of a drill pipe and into which the pumping sub is insertable via an opening at an in use lower end thereof, an upper portion of the sleeve including one or more passages providing fluid communication between the interior and exterior of the sleeve whereby on insertion of a said sleeve containing a said pumping sub into a said drill pipe, so that the level of fluid reaches the or a said passage, the said fluid flows into the sleeve above the pumping sub to equalise fluid pressure on either side thereof and permit subsequent removal of the sleeve from the pumping sub.

12. An apparatus according to Claim 11 wherein the sleeve includes a vent that in use lies above the said passage.

13. An apparatus according to Claim 11 including one or more exterior

projections that in use of the apparatus lie above the said passage and engage a drill pipe into which the sleeve is inserted, thereby retaining the sleeve at the top of the drill pipe.

14. A pumping sub generally as herein described with reference to and or as illustrated in the accompanying drawings.

15. An apparatus generally as herein described with reference to and or as illustrated in the accompanying drawings.

**Application No:** GB 0031753.7 **Examiner:** Joseph Mitchell
**Claims searched:** 1-10 **Date of search:** 28 March 2001

## Patents Act 1977
## Search Report under Section 17

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): E1F (FHJ, FKD, FKE), F2P (PG1)

Int Cl (Ed.7): E21B

Other: EPODOC, WPI, JAPIO

**Documents considered to be relevant:**

| Category | Identity of document and relevant passage | | Relevant to claims |
|---|---|---|---|
| X | GB 2065260 A | INSTITUT FRANCAIS DU PETROLE (Pg 2 lines 81-108, pg 3 lines 66-79, figs 1A and 1B) | 1-3 |
| X | GB 1321152 A | ENTREPRISE DE RECHERCHES (Pg 1 lines 58-81, pg 2 lines 10-36) | 1-2 |
| X | GB 1016160 A | OTIS ENGINEERING (Pg 5 lines 91-108, fig 1) | 1-2 |
| X | GB 0958734 A | SHELL INTERNATIONALE (Pg 2 lines 70-100, pg 2 line 100 - pg 3 line 35, figs 1 and 3) | 1 |
| X | GB 0942343 A | SHELL INTERNAIONALE (Pg 2 lines 31-124) | 1 |
| X | US 5549159 A | SHWE ET AL.(Col 5 lines 9-19, fig 2) | 1-3 |



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| X | Document indicating lack of novelty or inventive step | A | Document indicating technological background and/or state of the art. |
| Y | Document indicating lack of inventive step if combined with one or more other documents of same category. | P | Document published on or after the declared priority date but before the filing date of this invention. |
| & | Member of the same patent family | E | Patent document published on or after, but with priority date earlier than, the filing date of this application. |